that law pervades the universe, and although we do not know as yet the way in which these laws are balanced to produce all phenomena, that they are so balanced as to produce harmony, and that in proportion as the human mind develops it will be capable of grappling with problems that are not now within its reach.

## LIFE BEFORE FOSSILS.

By Charles Morris.

(*Continued from page* 188.)

Such a new stage of existence may have been essayed frequently. The dwellers in the early seas, in their descents below the surface, must often have come into contact with the bottom, and at times temporarily rested upon it. This contact with hard substance doubtless produced some effect upon them, and certain variations in structure may have proved of advantage in these new circumstances and been retained and further developed. Particularly if food was found there, and habitation on or near the bottom was thus encouraged, would such favoring variations tend to be preserved.

But, as has been said, myriads of years may have passed in the slow development of swimming pelagic animals before this phase of evolution was completed. And, perhaps, not until this was fully accomplished did contact with the bottom set in train a new series of changes, and in time give rise to the greatly transformed bottom-dwellers. The change, indeed, was a great one, if we may judge by the wide diversity in character between the swimming embryos and the mature forms of oceanic invertebrates, and must have needed a long period of contact with the bottom for its completion. Yet it was probably much more rapid than had been the preceding pelagic development. Contact with solid substance was a decided change in condition, and may have greatly increased

the preservation of favorable variations. And the area of habitation on the single plane of the sea bottom is so restricted as compared with that within the many planes of oceanic waters, that the struggle for place and food must have been greatly increased, and the development and preservation of newly adapted forms have been more rapid in consequence.

This may seem to bring us to the very verge of the kingdom of life as it is known to us from the oldest fossils yet discovered. Yet in truth we are probably still remote from it. We are still dealing with soft bodied animals, not with those possessed of the hard external skeletons from which fossils are produced. There is no good reason to believe that mere contact with the earth induced the previously naked swimmers to clothe themselves in solid shells. In truth, the earliest bottom-dwellers may have long continued soft bodied, the hard case or shell being only slowly evolved. The mantle of the mollusk, for instance, with its shell-secreting glands, is not likely to have been a primary accessory of molluscan organization. The same may be said of the chitin-forming glands of the crustacea, and the analogous glandular organs of other types. Such conditions must have developed slowly, and their appearance was probably due to an exigency of equally slow unfoldment.

For now we come to another highly important problem, that of the true disposing cause of the development of dermal skeletons, on which there exists some basis for speculation. In truth the fossils preserved for us in the Cambrian rocks have an interesting tale to tell which has a strong bearing upon the story of animal evolution. And this is, that all these bottom-dwellers, with the exception of the burrowing annelids, became covered with what was probably defensive armor. They all seem to have sought protection in one way or other, and in so doing became in a measure degenerated forms of life, their former ease of motion being now partly or wholly lost.

All this represents an interesting stage in the process of evolution, and indicates some special exigency in life conditions which the animals of that age could only meet by rendering themselves heavy and sluggish with a weight of inclosing

armor. This new phase of evolution may have proceeded very rapidly, many forms of early life disappearing, while those that quickly became armored survived.

What was this exigency? Protection, apparently, as is above stated. But protection from what? Against what destructive foe did these ancient animals need such strong defence? Which among them was the rapacious creature whose ravages imperilled the existence of all the others? Certainly not the sponge or the cœlenterate; they feed on smaller prey. The mollusk or the echinoderm, in their agile unclad state, may have been actively predatory, but they were among those forced to seek protection. Of the known forms the trilobite seems most likely to have been the aggressive foe in question. It was the largest, the most abundant, and, perhaps, the most active of them all, its size and numbers indicating an abundance of easily obtained food, while its great variety of species points to the existence of varied conditions of food or methods in food getting.

To all appearances the trilobite was then the lord of life, the Napoleon of that early empire. Awkward and clumsy as such a creature would appear now, it was then superior in size, strength, and probable agility to all other known animals, while its numbers and variety indicate that it was widely distributed and exposed to all the varying conditions of existence at that time. What a hurrying and scurrying there must have been among those small soft creatures to escape this terrible enemy, from whose assaults nothing seems to have availed them but an indurated external covering, too hard for its soft jaws to master. As the prey became protected in this manner the destroyer probably improved in strength of jaw, and there may have been a successively more complete growth of protective devices in the prey and of powers of mastication in the foe. And thus arose the conditions which first made fossilization possible, in the development of a series of armor-clad creatures which were really late comers upon the stage of life, remote as they seem when measured by our standard of time.

But the story is only half told. The trilobite, as it is known to us, is under armor also. Not only is it clothed in a dermal

skeleton, but, in its later forms, is capable of rolling up into a hard ball with no part of its body exposed. Evidently the destroyer himself in time came into peril and needed protection. Some still more powerful and voracious foe had come upon the field, and the triumphant trilobite was forced to acknowledge defeat.

We cannot well imagine any of these animals assuming such armor except for protective purposes. The weight laid upon them rendered them slow and sluggish, fixed some of them immovably, and greatly decreased their powers of foraging. The only cause which seems sufficient for their assuming this disadvantageous condition is that of imminent peril—a peril which affected all known forms alike.

Whence came this peril? Where is the voracious foe against whom they all put on armor, even the preceding master of the seas? No trace of such a creature has been found. In truth, we cannot fairly expect to find it, since it was probably destitute of hard parts, and left behind it nothing to be fossilized. It had no foe and needed no armor, while lightness and flexibility may have been of such advantage to it that armor would have proved a hindrance. It probably was a swimming creature and thus left no impress of its form upon the mud. It is to this unknown creature that we must ascribe the armored condition of all known forms of life at that period, even the later cephalopods, large and powerful mollusks, becoming clothed in a cumbrous defensive shell, which they were obliged to drag about with them wherever they went.

It is a strange state of affairs which thus unfolds before our eyes. All the life we know of seems diligently arming itself against some terrible enemy, which itself has utterly vanished and left as the only evidence of its existence this display of universal dread. The creature in question would appear to have been without internal or external hard skeleton and without teeth, trusting to indurated jaws for mastication. At a later date, when its prey became less easily destroyed, teeth may have developed, and it is possible that we have remains of them in the hard, cone-like, minute substances found in the lower Silurian strata, and known as conodonts.

If we may try and rebuild this vanished beast of prey from conjecture, aided by collateral evidence, we should consider it an elongated, flexible form, developed from some swimming worm-like ancestor, perhaps like the Ascidian embryo, stiffened internally by a cord of firm flesh extending lengthwise through the body, and moving not by cilia, but by the aid of fleshy side flaps, the progenitors of the fin. We conjecture it to have been, in short, the early stage of the fish, a creature perhaps of considerable size and strength, due to the abundance of easily obtained food, but as destitute of hard parts and as little likely to be fossilized as Amphioxus.

We may offer this conjecture with some safety, for it is not long before we come upon actual traces of fish, and of a degree of development which indicates a long preceding stage of evolution. In fact, the fish in time appears to have been forced to put on armor, as its prey had earlier done. Internicine war began in the fish tribe itself. A wide specific variation arose, with great differences in size and strength, the stronger attacked the weaker species, and eventually two distinct types of fish appeared, the Elasmobranch and the Ganoid; the former, represented to us by the modern sharks, being much the most powerful and voracious, and holding the empire of the open seas, while the latter dwelt in shallower waters. The Ganoids, preying on the bottom forms, become themselves the prey of their strong and active kindred, and, as a result, the evolutionary process just described was resumed. The weaker fish put on armor, in many cases heavy and cumbrous, a dense bony covering which must have greatly reduced their nimbleness, but which safety imperatively demanded. It is these armored forms that first appear to us as vertebrate fossils; the first fish, as the first mollusk or crinoid known to us, being the resultant of a very long course of development. As regards the Elasmobranchs, they, too, became in a measure protected, though not sufficiently to indicate any very active warfare among themselves.

There is little more which we can say in this connection. The story of the evolution of life bears an analogy worth mentioning to that of the development of arms of offense and de-

fense among men. After thousands of years of war with unarmored bodies, men began to use defensive armor, the body becoming more and more covered, until it was completely clothed in iron mail, and became rigid and sluggish. In the subsequent period offensive weapons became able to pierce this iron covering, and it was finally thrown aside as cumbrous and useless. A similar process is now going on in the case of war vessels, they being clad in heavy armor, which may yet be rendered useless by the development of cannon of superior piercing powers, and be discarded in favor of the light and nimble unarmored ship.

The analogy to animal evolution in this is singularly close. After long ages of active warfare between naked animals, defensive armor was assumed by nearly every type of life, except the lowest, highly prolific forms, and the highest, which had no foes to fear. But the powers of offense grew also, and in time the employment of armor ceased, as no longer available, its last important instance being that of the ganoid fishes. The later fish reduced their armor to thin scales, and gained speed and flexibility in proportion, while in land animals armor was seldom assumed. In several instances creatures have gone back to the old idea, as in the armadillo, the porcupine, the turtle, etc., but the thinly clad, agile form has become the rule, armor no longer yielding the benefit that was derived from it in the days of weak powers of offense. This result is a fortunate one, since with increase of agility mental quickness has come into play, the result being a development of the mind in place of the old development that was almost wholly confined to the body. In the highest form of all, that of man, physical variation has almost ceased, in consequence of the superior activity of mental evolution.

In conclusion it must be admitted that there are certain formations in nature which seem to militate against the argument here advanced. I have already spoken of the much questioned Eozoon canadense. In addition there are the beds of limestone and graphite in the Laurentian formation. But these prove too much for the advocates of their organic origin. If so large a fossil as Eozoon had appeared so early, the subse-

quent barrenness of the rocks would be incomprehensible. And had coral animals and large plants capable of producing such masses of limestone and graphite existed so early, the absence of any fossils earlier than the Cambrian would be inexplicable. It is acknowledged, however, that such formations might have been produced by inorganic agencies, and the facts strongly indicate that such was their origin, and that fossils began to be preserved very shortly after the power in animals to secrete hard skeletons appeared.

---

## BIRDS OF NEW GUINEA (FLY CATCHERS AND OTHERS).

By G. S. Mead.

(*Continued from page* 195.)

The Thickheads (*Pachycephala*) are of many species and scattered widely over the Archipelago. Many have come under trained observation only during recent years. Probably many more await discovery.

*Pachycephalopsis poliosoma*, Gray Thickhead, was discovered by Mr. A. Goldie in Southeastern New Guinea, and owing to its distinctive coloration was classed as a new genus. It is really one of a group of birds which might form a subgenus and is accordingly so divided by Mr. Gadow. Above the general color is dark gray, almost brown, with the head still darker. The square, rather short tail is also dull of hue. Beneath is dull gray, lighter on the abdomen and tail coverts, whitish to white on the jugulum, throat, chin and side face. It is a pretty, soft colored little bird about 6 inches long, sufficiently numerous among the mountains of the Astrolabe range to be called common.

*Pachycephala melanura* ranges widely over Northern Australia and the Archipelago. The general color above is olive-green ; wing coverts, tail, head and an irregular band passing